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COMPUTER MANAGED INSTRUCTION IN ELEMENTARY SCHOOL MATHEMATICS: UNDERSTANDING THE IMPLEMENTATION

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled

COMPUTER MANAGED INSTRUCTION IN ELEMENTARY SCHOOL MATHEMATICS: UNDERSTANDING THE IMPLEMENTATION

submitted by Stephen John Kemp in partial fulfilment of the requirements for the degree of Master of Education.

To my wife, MaryLynn, whose love and companionship made all of this possible and worthwhile.

ABSTRACT

The purpose of the study was to attempt to understand the process of implementing a microcomputerized management instructional system in elementary school mathematics. Based upon an instructional data base consisting of a hierarchy of objectives for each of the four computational operations, a CMI system was designed and authored for the Apple II Plus microcomputer which afforded comprehensive manipulation of data for instructional decison-making purposes. The nine week study, undertaken in seven classrooms spanning grades three to six, revealed the relative importance of confidence-building and routine, mechanical usage of the innovation upon the degree of incorporation. The confidence of the teachers was dependent upon a motivation to participate, the reliability of the innovation, an awareness of the program's capabilities, a conceptualization about who should use the program and how that use might best be organized, and the availability of, and accessibility to, a consultant. The second theme, the accommodation or establishment of the innovation, was at once the means of producing, and the product of, the growing confidence that the participants

felt in themselves and the innovation. The establishment phase was dependent upon the availability of the computer, guided by the need of the teachers to use the management components of the program, and illustrated by routine, democratic use. The third dimension was the incorporation of the innovation into the instructional strategy of the participants, a lock-step sequence of uses that grew in sophistication from the assigning of objectives to the grouping of students based on achievement. The themes are represented in a three dimensional model of implementation which conveys the interrelatedness of the categories of one dimension with those of the other two.

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I cannot adequately express my sincere thanks to the following people whose friendship, support and encouragement are between each and every line.

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The nature of man's interaction with machines has been revolutionized by the development of computer technology. The pervasiveness of computers means that we now encounter them in almost every aspect of our lives. The implications of computer technology for education, however, are still in what may be described as a formative stage. We are in the position of being able to identify the potential of computers for education, and the means and methods by which we might incorporate this technology into teaching. Rather than reacting to a given state of affairs, we have the opportunity to determine the nature and direction of computer use in the classroom.

The growth of computer technology in both elementary and secondary schools has been phenomenal, yet continues to accelerate as more capable and less expensive technology becomes available. Estimates of this growth have invariably underestimated the rate of incorporation and the types of applications. While the implication for educators is to somehow manage a veritable revolution to maximize the potential of the technology for the benefit of both students and

teachers, the difficulty arises, however, in the possible uniqueness of the implementation of a technological innovation as opposed to a "paper" one. Such a fact, which has only recently emerged, is perhaps crucial to the future plans for the incorporation of computer technology into education.

PURPOSE OF THE STUDY

This study is an attempt to understand the process of the interaction of man and machine, specifically, the use of microcomputer as an aid(e) for the teacher in the daily management of elementary school mathematics instruction. The study focuses on the design, development, introduction, and the implementation of a computerized management system into seven classrooms spanning grades three to six.

OVERVIEW OF THE STUDY

As an account of the implementation of an innovation from the perspective of one who was at the same time the creator, author and implementer, it is imperative that the assumptions and specifications

of the innovation, the background of the researcher/ author/implementer, and the nature of the research design constructed to make sense of the process of implementation be clearly outlined so that the interpretation of the data can be undertaken in proper context. Accordingly, chapter II deals with the background to the study, specifically, the instructional cycle for which Computer Managed Instruction (CMI) is most appropriate, the concept of CMI itself, the process of implementation, and the research methodology employed. Chapter III is a description of the evolution of the research design, including the curriculum and program development, the research setting, the implementation strategy, the role of the researcher, and the data collection. Chapter IV deals with the interpretation of the data and the presentation of the model of implementation which I feel captures the essential themes which were at work during the study. Chapter V includes a summary of the study and a discussion of the findings, while Chapter VI outlines the possible implications for researchers and educators, and presents a concluding statement.

CHAPTER TWO

BACKGROUND TO THE STUDY

Analagous in many respects to the concept of figure and ground, the research study which slowly emerged from the context was a fusion of elements, a combination of attitudes, interests and assumptions unique to this researcher. It was very much a product of my five years teaching experience in the primary grades, an experience which nurtured in me the belief that the essence of teaching is the personal interaction between teacher and student. It was a function of my interest in, and awe of, the phenomenal growth in the capacities of microcomputer technology, a veritable bottomless well of potential for educators just waiting to be tapped. And it was the assumption that the best use for this technology lie in relieving the teacher of the more routine, mechanical functions which demand so much time and effort. Thus, the specific characteristics of the study were determined to a large extent by my aim to integrate computer technology into education, with the goal of enhancing the daily routine of teaching to permit more personal interaction between the teachers and students.

While the general nature of the study (the context) was quite firmly established before the study was developed, the form and substance of the study (the figure) grew as my knowledge of the technology and research in general increased, and my perceptions of what could or could not be done and how best to effect such changes, matured. From the global approach to implementing computer technology in education which Valaskakis (1981) referred to as the process-impact effect (pp. 4), I chose to concentrate on the management component of assisting instruction, commonly referred to as Computer Managed Instruction, or CMI. Once a framework was established which gave structure to the general goal, the process of defining the study, altering, adding, or deleting components, rethinking and reformulating my intentions, produced the form and substance of the study. Slowly the means to the end became clear, and the study began in earnest.

To more fully explicate the theoretical base upon which the resultant study rests, I will endeavour to describe the instructional cycle for which CMI is most appropriate, the concept of Computer Managed Instruction, the process of implementation, and the research methodology employed.

THE INSTRUCTIONAL CYCLE

The form and type of instruction best suited to incorporating a CMI system is a reflection of a definitive concept of curriculum theory and instruction which may best be characterized as the "means-ends" approach. The role of the teacher is to provide or determine the goals or learning outcomes, teach to achieve those ends, and evaluate the success of the process. In so doing, the teacher is both an educational delivery vehicle, and the manager of an instructional system (Baker, 1977, pp. 247). Within the latter, there are two distinct levels of activity.

> One of these is supervisory style management which mostly involves clerical activities that many of us expect to see teachers doing. Functions such as recording, assigning, evaluating, arranging and reporting all are activities known to the classroom teacher. These activities all are, by nature, quite routine, but consume rather significant amounts of time. The second level of management activity required in education is much more sophisticated. It involves the truly managerial functions of planning, organizing, commanding, coordinating, and controlling (Dennis, 1979, pp. 1).

It is the purpose of a CMI system, then, to utilize the computer in order to optimize the learning environment and to maximize the educational progress for each

child while making efficient use of school resources: human, financial, and material (Spuck & Bozeman, 1978, pp. 33). The incorporation of the computer into the instructional cycle is illustrated in the model below.

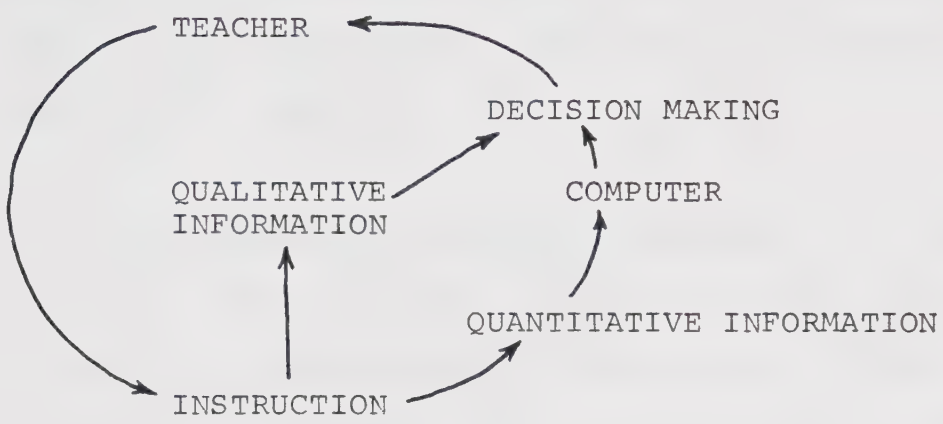

Figure 1. A model of Computer Managed Instruction within the instructional cycle.

The information generated by instruction may be either qualitative (perceptions, feelings, intuitive knowledge) or quantitative (student test results) in nature. The microcomputer, in using a CMI package, assumes the bulk of the quantitative data storage and analysis, the assumption being that better educational decisions can be made if timely and appropriate information is available (McIsaac & Baker, 1981, pp. 46).

COMPUTER MANAGED INSTRUCTION

Computer Managed Instruction is an educational system composed of the following six components: curricular plan, instructional model, diagnosis and prescription, management, reporting, and computer (Baker, 1977, pp. 21).

The curricular plan most appropriate for a CMI system is based upon the cognitive processes approach to curriculum development. This approach to curriculum is primarily concerned with the refinement of intellectual operations, focusing upon the how rather than the what of education (Eisner & Vallance, 1974, pp. 5).

The instructional model which incorporates CMI involves a potentially radical reorganization of the traditional roles of the teacher as mass lecturer and the student as one of a number of passive respondents. While admittedly providing a somewhat inadequate description of the intricacies involved in managing instruction, nonetheless, the following diagram based ona model of CMI proposed by Rushby (1979, pp. 55) captures the essential steps in the theoretical implementation of such a system into an elementary

school classroom.

THE STUDENT	THE COMPUTER	THE TEACHER
1. COMPLETES ASSIGNMENT	1. GENERATES TEST	1. INSTRUCTS
2. TAKES TEST	2. RECORDS RESPONSES	2. ASSIGNS A TEST
3. RECEIVES FEEDBACK	3. EVALUATES RESPONSES	3. DIAGNOSIS
4. REPORTS TO TEACHER	4. ASSIGNS INSTRUCTIONAL GROUPS	4. DETERMINES GROUPS
	5. GENERATES PRESCRIPTION AND PRINTOUT	
	6. UPDATES RECORDS AND STUDENT DATA	

Figure 2. A model of the roles of the teacher, student, and computer in a Computer Managed Instructional system.

In an ideal CMI environment, there would be a smooth partnership between the teacher, the student, and the computer. The teacher, freed of the administrative burden, would be able to devote his time to the task of helping students for which he was trained, and hopefully enjoys; the student would enjoy a course of

study which was tailored to his individual needs and preferences, with ample feedback to guide his studies; the computer, having no need of job satisfaction, but able to process information quickly and accurately, would take over the routine management of the courses (Rushby, 1979, pp. 52).

There are two types of diagnosis - symptomatic and causative. A symptomatic diagnosis is at a descriptive level, while a causative diagnosis is one which the mechanism underlying the symptoms can be identified (Baker, 1977, pp. 300). Unfortunately, limitations inherent in the capabilities of the most common and popular microcomputer systems to store, manipulate and retrieve the enormous amounts of code and data required for a causative diagnosis component, have necessitated the use of symptomatic diagnosis.

The management of the instructional cycle refers to those capabilities within the program to analyse, monitor and direct each individual student's progress, or that of the class as a whole. The management aspect is based upon the records gathered and retained by the program while interacting with the students.

The report function of the CMI system is the generation of individual, group, or comparative data controlled by the teacher and illustrating the student's progress in the instructional data base. The reports constitute the medium by which instructional decisions are made regarding the future activities.

The application of CMI packages to education has essentially been attempted with the use of large computer systems because of the greater data storage capacities, and the power of authoring languages which facilitate the authoring and revision of the program. However, recent technological innovations which have expanded the power of microcomputers, in conjunction with the inappropriateness of large, expensive systems for most school districts, have stimulated the development of CMI systems for microcomputers. This study is using such a small configuration, namely the Apple II Plus.

IMPLEMENTATION

> Implementation does not involve merely the direct application of a technology. Implementation is an organizational process that implies interactions between

> the project and its setting; thus, it is neither automatic nor certain (Berman & McLaughlin, 1976, pp. 352).

Implementation is a process, and process implies change. The changes in both the structure or usage of an innovation and in the innovators are the result of the interactions between the various elements to which, or within which, the implementation is introduced. The degree of change cannot be predicted with certainty.

> There are definite variations in the degree to which the same innovation is implemented by different individuals and organizations, and the degree to which some components of an innovation are implemented more effectively than others (Fullan & Pomfret, 1977, pp. 345).

The importance of the elements in the implementation process cannot be understated. Common (1979) has identified four such elements fundamental to every implementation process.

> 1. A Curriculum: The nature of the curriculum, specifically its complexity, explicitness, and practicality affect the implementation process.
>
> 2. A User of the Curriculum: There are three characteristics vital to ensuring the success of the implementation; (a) a knowledge or an

> understanding of the curriculum; (b) the capabilities and skills to implement; and (c) the motivation to implement. In addition, the teacher performs three functions in the process, those being the planning for the use of the curriculum, the performance in carrying the plan through, and monitoring and evaluating the progress of the implementation.
>
> 3. A Manager of the Implementation Process: The manager must possess the qualities of leadership, commitment to and a belief in, the innovation, and a thorough knowledge of the innovation. The functions of the manager include planning of the innovation prior to, and during the implementation, coordination of the implementation, evaluation, and providing motivation.
>
> 4. A Receiving Organization: The receiving organization must be adaptive, innovative, and receptive to change. It must also provide a temporary system to implement which is receptive to change, provides morale, and satisfies the needs of the innovators during the implementation process (pp. 2-13).

The inherent complexity of the implementation process, in this case the introduction of a technological innovation into a social setting, means that during the course of the study a myriad of factors could influence the process one way or another. Fullan and Pomfret (1977), and Berman and McLaughlin (1976) have identified several determinants of implementation, factors which have an important role as to the direction and degree of impact of the innovation. Fullan et al. (1977) noted the characteristics of the innovation

(explicitness, complexity) strategies (in-service training, resource support, feedback mechanisms, participation), and characteristics of the adopting unit (adoption process, organizational climate, environmental support, demographic factors) as being instrumental in the implementation process (pp. 367). Berman et al. (1976), in evaluating change-agent programs noted that "the extent of mutual adaptation that occurred depended on the substance and scope of change proposed by the project design, particularly how complex and specific the methods and goals were, and flexibility in coping with unanticipated implementation problems." (pp. 353)

The underlying theme which pervades the discussion of the process of implementation is that the interactions between the elements is the one single crucial factor in its direction and effect. Consequently, the task of the researcher then is to construct a research methodology capable of "analyzing the complexities of the change process vis-a-vis how innovations become developed/changed during the process of implementation." (Fullan et al., 1977, pp. 340)

QUALITATIVE RESEARCH METHODOLOGY

> Qualitative methodology refers to those research strategies, such as participant observation, in-depth interviewing, total participation in the activity being studied, field work, etc., which allow the researcher to obtain first-hand knowledge about the empirical social world in question. Qualitative methodology allows the researcher to "get close to the data," thereby developing the analytical, conceptual, and categorical components of explanation from the data itself (Filstead, 1970, pp. 6).

The rationale underlying the use of qualitative methodology in research is based on the assumption that we cannot understand human behavior without understanding the framework within which the subjects interpret their thoughts, feelings and actions (Wilson, 1977, pp. 249). Understanding, therefore, can only come from a close and personal relationship between the researcher and the situation. The difficulty which immediately confronts the researcher, however, is in maintaining a perspective that views events from without as well as from within, while at the same time being close enough to the situation to be sensitive to the underlying forces at work. As both participant and observer, the researcher is faced with two types of problems: the tactical problem of maneuver in the

field (conformity or nonconformity), and the evaluation of the data (the observer's experience as related to the imputation of meaning and the formulation of categories) (Vidich, 1970, pp. 169).

As an integral part of the situation, the researcher must be careful to acknowledge, and elaborate upon, the influence he exerts on the data which is both generated and interpreted. Accordingly, the researcher must first find out where in the social structure he fits and what role the participants have established for him, for the role of the participant observer and the images which the respondents hold of him are central to the definition of his social position; together these two factors shape the circumstances under which he works and the type of data he will be able to collect (Vidich, 1970, pp. 244). The researcher cannot, for reasons of objectivity, attempt to become one of the participants, but neither can be appear aloof or removed, for proximity to the situation will determine the accuracy of the data collected.

The evaluation of the data is the researcher's

attempt to categorize in some form the events of a situation so that insights into the meaning of a situation become clear. Evaluation is not an entity unto itself undertaken retrospectively, rather, it is an on-going process of formulating hypotheses, clarification, substantiation, and re-formulating new hypotheses. Often what is sought, and how, is a product of the researcher's background, experiences, and attitudes.

> In short, in qualitative work, just as there is no clear-cut line between data collection and analysis (except during periods of systematic reflection), there is no sharp division between implicit coding and either data collection or data analysis. There tends to be a continual blurring and intertwining of all three operations from the beginning of the investigation until its near end (Glaser & Strauss, 1970, pp. 291).

As the insights into the situation slowly emerge, the task then becomes one of conveying the interpretation in the form of a model or figure. Once a paradigm is grasped, understood, and used, then the results or research are presented in such formulations or conceptualizations as are deemed necessary, and no argumentative or comparative posture which argues that this approach is "better" or "more valued" or "truer

to life" than some other is mentioned (Psathas, 1973, pp. 17).

While the ultimate goal of qualitative research is the construction of a paradigm to represent the essential themes of a situation, both the means to that end and the form and nature of the end itself are unknown as the research begins. The particular means chosen will depend on the theoretical requirements of the research design, on the characteristics of the place and population to be studied, and in no small measure on the personal and professional qualifications of the investigator (Pearsall, 1970, pp. 345).

CHAPTER THREE

THE RESEARCH DESIGN: EVOLUTION OF THE CONSTRUCT

The research design was, from the moment of conception to its conclusion several months later, very much a construct in evolution. The dynamics of change began with the transformation of the theoretical into the actual and continued as the actual developed over time. This process of change continuously provided new structures which in turn became the context from which more developments emerged. Ends were not ends unto themselves, but the means for yet more ends.

> Ends arise and function within action. They are not...things lying outside at which the latter is directed. They are not ends or termini of action at all. They are terminals of deliberation, and so turning points in activity (Dewey, 1922, pp. 223).

The activity which represented the evolution was a reciprocity of action between elements (program and curriculum development, the research setting, the implementation strategy and the role of the researcher) which determined both the character

and direction of the research design. This interaction was at times internal or external in origin, implicit or explicit in nature, pro-or re-active in effect.

As the design unfolded, the original assumptions regarding the nature of the teaching act, curriculum theory and development, and the role of technology in a classroom environment, were noteworthy for their stability even as the form of those assumptions was being moulded over time. The foundation upon which the research design was based allowed for adaptation without jeopardizing the integrity of the construct.

CURRICULUM DEVELOPMENT

The very fact that a CMI system was deemed appropriate for use in teaching elementary school mathematics implies a definitive concept of teaching and curriculum, a paradigm of instruction adhering strongly to the purposes, experiences, organization and evaluation model advanced by Tyler (1949, pp. 1). The problem of the educator and curriculum specialist,

then, is to identify the most salient and efficient intellectual processes through which learning occurs, and to provide the setting and structure for their development (Eisner & Vallance, 1974, pp. 6). The setting and structure for the development of the pupil's computational skills was, in the larger context, the CMI system itself, of which a hierarchy of objectives compatible with the curriculum of Alberta, Saskatchewan, and the Saskatoon Catholic Board of Education was its substance. The objectives once selected, were arranged within each operation in a sequential, progressive, linear manner. The scope of the objectives was limited, however, by constraints inherent in the technological medium being employed. (see Appendix A).

Whereas the original conceptualization of curriculum and instruction and its embodiment in the selection and organization of objectives remained stable for the duration of the study, other aspects of the research design were a study of intentionality constantly being tempered by realism.

PROGRAM DEVELOPMENT

From Baker's model of CMI as being composed of a curricular plan, instructional model, diagnosis and prescription, management, reporting, and computer (1977, pp. 21) emerged a program written in the BASIC language designed to meet those general specifications. Accompanied by the instructional data base (consisting of the objectives for each of the four operations), the CMI package provided the following:

1. Student files and retrieval capacity.

2. Consideration of instructional goals, individual capabilities, and instructional means.

3. Diagnosis and prescription of a course of instruction for the learner.

4. Test scoring.

5. Information from the data base in a reasonable and usable form.

6. Monitoring of each student relative to his program of objectives and to other students in the class.

7. Management of the resources required for classroom operation.

8. Management reports for administrators describing the educational growth of students in the classroom (Aguilu & Bitter, 1973, pp. 7).

The management of the instructional cycle was accomplished by five programs within the CMI package which allowed the teacher to administer to any one of the following: the class as a whole, an individual student, the prescriptions and objectives, the printed reports, and the class or student performance data stored during the course of the CMI system's operation. (see Appendix B).

There were two reports generated by the CMI system - both intended for use by the teacher - one immediately after the student had scored his test responses, and the other at the convenience and need of the teacher. The report which was produced for each student after they had interacted with the system included pertinent information designed to provide the teacher with individual and comparative data upon which better educational decisions could be based. (see Appendix C). Also available to the teacher upon request were printed reports on individual students (biography, history, assignment and instructional group), the class (progress in objectives, operations and groups) or the objectives and prescriptions.

Revisions to the capabilities and capacities of

each of the five programs and the test generation/ scoring cycle were initiated by variety of sources, not the least of which were the limitations of the technology itself. In particular, the test generation routine which originally was intended to be an on-line, interactive procedure, became a hard copy, printed test using the Apple Silentype thermal printer. The storage capacity of the microcomputer both in terms of random access memory and diskette meant the fractionalization of the whole program into sub-programs. Consequently, accessing of programs from disk involved delays which in the words of one participant "became very annoying at times", even though every effort had been made to maximize the functionality and utility of every option within each program.

Further revisions were initiated by findings obtained from the pilot study, conducted two weeks before the CMI package was scheduled to be introduced into the research setting. The participating teacher employed the CMI package in a way that had not been anticipated. Specifically, the students went to the computer, a test based on the progress of the student or the teacher's assignment was

produced, the student completed the test on-site, and corrected the test on the computer before returning to their seat. This deviated from the original intention of having each child receive a test in succession, and then repeat the cycle for test scoring purposes. The implications of this novel approach were considerable delays while the computer accessed, retrieved, manipulated and updated information used in record-keeping. In response to this situation, the efficiency of the test generation and scoring routine was enhanced both in terms of the method of data manipulation and time.

Another facility proposed by the cooperating teacher and subsequently incorporated into the class management program was a routine for grouping students using either achievement, or name. At this point, however, the limited storage capacity of both the random access memory and diskette necessitated a decision on my part as to the relative merits of the many components of the CMI package. The addition of one routine meant the elimination of another. Functional utility was paramount, thus a component of the CMI package which recorded the date of mastery

of an objective for reporting purposes was deleted in favour of the potential benefits to be derived from grouping students.

The molding of the program to fit the reality of the teaching situation continued past the pilot study and into the actual implementation process. After having worked with the program for three weeks, the seven participating teachers requested the elimination of the printed report generated at the end of the test scoring cycle. This report contained information as to the student, the operation and the objective, both the student's responses and the correct responses as recorded by the computer, instructional groups as determined by the teacher or automatically by the program, and five prescriptions which listed appropriate resources for teaching or remediating the concept. (see Appendix C). The teachers, without exception, felt that the printed report was of little value and only added to "the masses of paper we shuffle anyway." This opinion was based upon the ways in which the teachers had accommodated the innovation, specifically, a routine, democratic use of the machine with little regard for matching the instructional level of the students

to an appropriate objective level. This phenomenon will be discussed in much greater detail when we consider the underlying themes which characterized the study.

In conjunction with the actual CMI package as conceived, authored and revised, the model of the incorporation of computerized management into the instructional cycle represented the major data generating instrument from which insights into the implementation process slowly emerged.

RESEARCH SETTING

> Action is constructed by the actor; therefore, to understand how and why men act as they do, their perspective must be understood (Psathas, 1973, pp. 6).

Within the research setting there were a number of domains of influence: the community as a whole, the school in particular, the principal, the teachers, the students, and myself. The relative influence of each domain acting alone or in concert with others, was the catalyst which promoted the evolution of the research design during the entire length of the study.

To describe the community as a typical, middle class suburb is indeed an oversimplification, but nonetheless, portrays its essential characteristics. Approaching a decade in age (originally developed in response to industrial expansion close to an existing agriculturally based town), the area has now taken on the appearance of stability and maturity. The predominant occupation of the somewhat transient families would appear to be directly or indirectly dependent to a large extent upon the industrial base.

From the staff of eighteen teachers, seven voluntarily consented to participate in the research study. As a collective, few common traits could be detected among the seven, thus a dominant perspective is difficult to define. There were as many degrees of the variable "experience" as there were participants: teaching experience ranged from one to thirteen years; experience with the mathematics program they were currently using varied from a "first exposure" to seven years; and previous access to, or familiarity with, a computer spanned "never saw a real one before" to a cursory acquaintance with the PLATO computer at the University of Alberta. Individually, no one participant had a great deal of experience in all of

the above.

While acknowledging the diversity of experience which the participants brought to the study, nonetheless, some elements common to all can be identified. Of these, the most evident was the enthusiasm to participate in the study as a means of acquiring more knowledge about computers and their role in education. The basis for this motivation lay in the perceived need for the teachers and students alike to become more aware of the potential benefits to be derived from a technology which is rapidly assuming greater importance in our society. In addition to agreeing on the basic reason for their desire to participate, the teachers were similar in their teaching styles and methods in mathematics education.

When initially teaching a mathematical concept, the three grade three teachers, the two grade four teachers, and the two grade six teachers taught to the group as a whole. No pre-testing was done on a routine basis nor was allowance made for students who had already mastered the concept being taught. The widely differing abilities of the pupils in each of the classrooms required each teacher to monitor the progress

of the pupils through a combination of unit or teacher-made tests, in-class or assigned work, and observation. Re-teaching of the concept, when called for as a result of the monitoring process, was generally done in a small group situation "when the need arose".

Each and every one of the one hundred and fifty-six students participating in the research study owned, or had direct access to, some form of integrated circuit technology, defined for the students as including calculators, electronic games, or microcomputers. Of these three, ownership or access to a calculator was the most prevalent (89%), followed by electronic games (60%) and microcomputers (0.04%). Distribution by grade level was insignificant for calculators and microcomputers, however, ownership of electronic video games increased dramatically according to grade level.

The pervasiveness of computer technology amongst the students and the familiarity of every student with at least one variation of it, may help in explaining what one teacher noted as "total acceptance of it (the

computer), almost as if it had always been here...they love it". The sheer excitement of the students at the prospect of using the microcomputer can be illustrated by statements from the teachers such as "they were on the edge of their seats all week," and "Monday couldn't get here soon enough for them, all I heard was 'When do we get the computer?' and 'How much longer 'til we get the computer?' and on and on and on!"

The research setting was the medium upon which I, as both data generator and interpreter, had both an explicit and implicit effect. In terms of the data generation and collection, at no time did I, nor could I, disassociate myself from the setting in an attempt to minimize my influence upon the situation. Similarly, as interpreter, the meaning I derived from a situation was very much a product of my history, experiences, assumptions and roles.

> Our observations are, therefore, always influenced by our prior conceptions; we view the world through our own perceptual lenses. These lenses have been partly ground by our exposure to and knowledge of theoretical constructs and formulations - if such exist - related to the research problem. There is no such thing, therefore, as atheoretical research (Duignan, 1981, pp. 292).

My own personal experiences in using a microcomputer in a teaching situation for the two years previous, the attitudes I held towards computer applications in the classroom, my assumptions about the relative merits of a CMI system, and the hundreds of hours spent authoring, testing and revising the CMI package, together colored my perceptions of events. Both my actions within the research setting as data generator and collector, and my actions outside of the research setting as synthesizer and interpreter, therefore, were to a large extent a function of the many roles I brought to the research study.

IMPLEMENTATION STRATEGY

In general terms, the study can be conceptualized as having two separate and distinct phases, the developmental (during which the students and teachers were familiarized with the microcomputer and the CMI program) and the implementation, or the actual introduction of the innovation into the seven participating classrooms.

The goal of the week-long developmental phase

was a "functional literacy" for both teachers and students, a working knowledge of the Apple II Plus microcomputer and the CMI program. Each classroom - both teachers and students - received a brief course of study which focused on the components, operations, uses and varieties of computers in three, one half hour lessons. I taught each of the lessons for all of the classrooms, using a lecture method supplemented by audio-visual aids such as overhead projections and thirty-five millimetre slides. In addition, each student was required to complete a small booklet which reinforced the major concepts discussed in the lessons. For their initial experience with the program, I was present with every student and teacher on an individual basis to demonstrate and explain. For the students, this meant actually directing them as they took a test and then had their answers scored on and by the computer.

Functional literacy for the teachers involved a more detailed extension of the literacy lessons to include a one hour inservice on the capabilities and operation of the CMI package itself. No effort

was made to suggest a means or a method of implementation other than the model of CMI based on the work of Rushby (1979), which was discussed briefly.

The quality and quantity of the implementation strategy (a personalized on-going process) was necessitated by the very nature of the innovation itself, a complex piece of machinery that while attracting the teacher also scared and frightened each of them to some degree. Therefore, I felt it necessary to assume the task of individually working with each student for every teacher so that the teachers were not left in control of an innovation about which they had little or no knowledge. Whether such an approach is merely appropriate for a "paper" curriculum but crucial to a technological one is open to debate, but the positive reactions of both students and staff to the method employed would certainly suggest that such is the case.

The second phase, the actual implementation of the innovation, at first involved drawing up a schedule for the sharing of the three microcomputer configurations. Ease of transport was a major factor

in the pairing of teachers, who eventually had the use of a computer each day for one half of the day. Once the schedule had been determined, the teachers were encouraged to begin the implementation in a manner which they deemed appropriate for their situation. The sharing of the microcomputers was eased somewhat by the purchase of an additional microcomputer by the school after the third week of the study. Thus, of the seven teachers, only four were required to share a computer while three others had full and daily use of their own machine.

I was present at the school every afternoon throughout the nine week study. My role changed daily, sometimes hourly, from that of creator and consultant to implementer and researcher. My duties varied accordingly, dependent to a large extent upon the smooth and reliable operation of the program, and the familiarity of both teachers and students with its operation. I therefore acted as the sole resource support and feedback mechanism, at least initially, until the confidence of the participants improved.

ROLE OF THE RESEARCHER

The perspectives which I was able to employ during the research situation were many and varied. A simple dichotomy of participant and observer as proposed by Wilson (1977, pp. 250) was not adequate for the purposes of this study; the participant was also the creator and author of the instrument for generating data, while the observer was once the implementer of, and consultant to, the CMI package. The conscious adoption of multiperspectives called for by Werner (1977, pp. 11), for the purpose of delimiting the effects of a myopic viewpoint, was therefore clearly necessary, indeed inherent, in the research design.

Viewing the research situation from without as well as from within, situational sense-making (Werner, 1977) requires the researcher to strike a responsive chord among people in dialogue situations by clarifying motives, authentic experiences, and common meaning (Aoki, 1978, pp. 12). In a systematic search to give meaning to meaning-making, the researcher must methodically plan the forms of data he will collect, the setting in which he will gather the

data, the participants with whom he will interact, and the questions he will ask (Wilson, 1977, pp. 257). The form of knowledge sought, therefore, is not nomological, law-like statements, but deep structures of meaning, the way in which man meaningfully experiences and cognitively appropriates the social world (Aoki, 1978, pp. 12).

The meaning of a situation, nonetheless, is unique to each individual. Perception, as the vehicle by which we seek to gain meaning, is a product of our own individual experiences, a history which has formed identifiable attitudes, principles, ideals and assumptions. This perspective, because it cannot be divorced from the researcher for the purpose of doing research, must be acknowledged, and more importantly, clearly defined. Wilson, (1977) viewed this process as being more than merely utilitarian, it becomes a means of objectively interpreting the insights which develop in a social setting.

> By systematically seeking to understand actions from the different perspectives of various groups of participants, the researcher avoids getting caught in any one outlook. He is able to view behavior

> simultaneously from all perspectives. These tensions in point of view - between outsider and insider and between groups of insiders - keep the careful researcher from lapsing into subjectivity (pp. 259).

The objectivity I sought, then was to be found in the multiperspectives which I brought to the research setting: creator, author, implementer, consultant, fellow teacher, and researcher. Each of these at times assumed paramount importance, yet at no time could they be totally disassociated from each other. The simple dichotomy of the increasingly important role of consultant, as was initially envisaged in the research proposal, could not be maintained during the course of the study. The dynamic interactions within the setting meant that at any one point in time, the role of researcher may have been but one part of a greater whole.

DATA COLLECTION

Data, as the building blocks of meaning, was the product of the complexities inherent not only in the communication between man and man (Aoki, 1978, pp. 11), but also in the interaction of man and machine. The

diversity of forms which the data assumed meant, therefore, that a variety of means was necessary to detect them.

An organizational matrix proposed by Spuck and Bozeman (1978, pp. 32) helped, at least initially, to structure the data collection (see Appendix D), but one whose importance gradually diminished as the study progressed. Employing questions from the matrix, the participating teachers were interviewed both formally and informally. The interview sessions, all of which were recorded and the dialogue transcribed, were held in places and at times most convenient to the participants, and varied in size from individuals to the full group. While each teacher was interviewed at least once a week on a formal basis, a definitive schedule was never established, dependent to a large extent upon the many demands placed on the teachers.

In conjunction with the interviews, daily observation of classroom settings provided the researcher with a vital source of data, most of which became the substance of an interview at a

later point in time and replacing the organizational matrix as the framework for questioning. As often as possible, I sought to remove myself from any direct contact with the participants while in the classroom, noting events and incidents in a log book. However, attempting to transcend myself from the research setting was, for this study, virtually impossible. I could not disassociate myself from the fact that I had created, authored, and was implementing the very innovation the effects of which I was studying. Similarly, the participants - both teachers and students - did not hesitate to ask for help or guidance when the need arose, thereby consciously subsuming my role as researcher with that of the many others I obviously portrayed.

While attempting to extricate myself as much as possible from guiding or influencing the course of the study, nonetheless, the fact remained that as consultant and implementer I was forced to actively participate in the research setting, thereby generating data while at the same time collecting it. For this reason, a purely phenomenological approach to the study could not be established, for integrity of the research role was impossible to maintain.

Similarly, I was not an outsider seeking to gain an understanding of the situation from a totally ignorant point of view, for my experience as a teacher served me well in empathizing with the participants and anticipating potential problems or concerns. Thus, while making the objectivity of my data much harder to protect, my familiarity with and active involvement in the research setting sensitized me as researcher to a deeper understanding of the situation, a familiarity based upon previous experience and personal commitment to the implementation.

As a means of reflecting introspectively on the daily events, I reserved a portion of time to myself to record my thoughts and feelings. While occasionally consisting of little more than a rote recollection of events, often I found myself considering in detail a particular comment or event and postulating as to its relevance and meaning. Accordingly, I would note the fact, and seek clarification of my interpretation at the earliest possible convenience.

Periodically throughout the term of the study concrete forms of data such as letters from the students

to myself, or any relevant artifacts which I considered as in some way having potential for making sense of the situation, were collected and retained. Duplicate copies of all the information were made whenever possible.

The variety of data collected was produced from distinctly separate sources: the teachers, the students, the school administration, other staff members, the community, and myself. Each group had slightly different perspectives of the same event, thereby interpreting the meaning of an event or happening in a variety of ways. The teachers and students were observed on a regular basis and interviewed directly. In terms of administration, the other staff members and the community, notes were kept on comments or events applicable to the implementation and clarification pursued whenever it appeared productive to do so. I, as both observer-researcher and participant-researcher, recorded my thoughts, actions and feelings on a daily basis, hoping to clarify my role in the situation, and constantly sensitize myself to the interactions amongst the participants. Periodic discussions with my advisor functioned as a means of clearly

defining the variety of roles I was assuming in the research situation, and their corresponding effects and influences.

CHAPTER FOUR

DATA INTERPRETATION

Just as there is no formula or recipe for procedures which is to be applied ready-made to the problem being studied (Psathas, 1973, pp. 16), there is no formula or recipe for analysis which would suffice for all research situations. The analysis - a process of insightful reflection upon the meaning of events from the perspective of the participants - is based upon the selection, classification, and definition of what constitutes "data" which in turn is a product of the assumptions, beliefs, interests and approaches the researcher holds implicitly or explicitly (Werner, 1977, pp. 1). The selection, classification and definition of the data is made more difficult by the variety of forms data may assume: verbal or non-verbal, active or non-active, concrete or abstract (Wilson, 1977, pp. 257). As the data are collected, the task then becomes one of ...

> analysis to find leads for further data collection and also to ascertain the existence of concepts. As a concept emerges, and as data begin to fit the

> concept, some of its properties, including its relationship to other concepts and the conditions under which it it pronounced and minimized, become discernible. With further collection, coding and analysis of data, some concepts are discarded or merged with more powerful and explanatory ones, while others are gradually refined and developed into a framework (Battersby, 1981, pp. 95).

The framework is the means by which we can substantiate whether the results of an inquiry fit, make sense, and are true to the understanding of ordinary actors in the everyday world (Psathas, 1973, pp. 12). Validation of the meaning, therefore, is requisite upon the validation of the classification system, a process which Lazarsfeld and Barton (1971) suggest must include the following:

1. Articulation: The classification should proceed in steps from the general to the specific, so that the material can be examined either in terms of detailed categories or of broad groupings, whichever are more appropriate for a given purpose.

2. Logical correctness: In an articulated set of categories those on each step must be exhaustive and mutually exclusive. When an

object is classified at the same time from more than one aspect, each aspect must have it's own separate set of categories.

3. Adaptation to the structure of the situation: The classification should be based on comprehensive outline of the situation as a whole - an outline containing the main elements and processes in the situation which it is important to distinguish for purposes of understanding, predicting, or policy-making.

4. Adaptation to the respondent's frame of reference: The classification should present as clearly as possible the respondent's own definition of the situation - his focus of attention, his categories of thought (pp. 142).

These efforts to establish a framework, or classification system, represented a necessary step in the struggle to understand the significance of a new paradigm, or, for that matter, to understand whether it was a new paradigm at all.

The paradigm which represents both the large and

small aspects of meaning was constructed in layers, beginning with what many times seemed at first to be nothing more than unrelated, trivial pieces of information. The difficulty was, that I entered the research setting not knowing what I was looking for, let alone the most appropriate way to begin the process of discovery. At times, promising comments proved to be of little value in a larger context, applicable only to that individual or at a particular point in time. Some comments, such as the one made by a teacher prior to the actual implementation suggesting a fear or nervousness on her part, were actually misleading. In general, however, the honesty of both the teachers and the students provided data which, even if they did not know it or could not verbalize it, was significant as indicating changes in thoughts or feelings.

In attempting to link together individual pieces of data in search of a deeper understanding of the underlying forces, or trends, I followed many blind avenues and pursued countless theories which profited me little. However, occasionally, I could see a theme emerge which seemed to convey a common sense of direction or accomplishment.

It was at these times that I sought clarification of what I thought I had heard or noted, and substantiation by asking for a group interview session so that I could present my interpretation to the participants for their analysis.

The deepest meaning which I was able to derive from the setting was a result of the linking of the themes. Sometimes these links were mutually productive, in other words positively interactive, at other times they were restrictive of each other. Time was of the greatest benefit and yet at the same time the greatest enemy of the uncovering of insights, for many aspects were excrutiatingly slow in developing or appearing. Once again, I pursued a variety of combinations in attempting to make sense of the relationships between the categories. In doing so, some relationships as I had envisaged them proved to be incorrect, while others I had not considered or at the time even discovered held more relevance and significance.

Whilst the meaning was appearing in a haphazard and inconsistent fashion, so too was the

relative importance of the various domains of influence (community, staff, students, teachers, and myself). During the literacy phase of the study lasting the first of the nine weeks, the overwhelming force was that of the students. Their enthusiasm was infectious, uplifting myself and the participating teachers alike. Gradually, however, their dominance faded except for a few isolated instances, assuming more of an underlying role than that of an overt, clearly demonstrable influence. In comparison, the teachers, who at first were somewhat resigned and cautious, gained in both confidence and influence. The community, the other staff members and the administration, on the other hand, were generally of little or no clearly recognizable importance. My influence, while it did not diminish to any great extent, varied in the direction of its effect as a consequence of the many roles which I brought to the study. During the literacy phase, I was the unquestioned expert, personalizing for some students, and perhaps for the teachers also, the technology I was introducing, as evidenced by the comment of one grade three student who exclaimed "It's Mr. Apple!" when I came into

the classroom! As the study progressed, difficulties both with the computer and the program forced me into the role of creator and author to correct whatever problems arose. At the same time, I was the implementer and as such was called upon for advice, all the while attempting to remain sensitive about the meaning of events and objective as to the reasons for those events happening.

Careful consideration of both the substance and the origin of the data gradually revealed categories which I felt accurately reflected the meaning of the situation as it unfolded. From these categories emerged themes, or dimensions, with threads of commonality binding them together which directed their influence in a uniform manner for the same general purpose. Finally, the relationships between these dimensions became apparent, but only after the original six week timeline was extended to nine on the request of the teachers did the nature of these slowly developing links mature and be recognized as such.

The framework which finally emerged, a product of the intense interaction between the participants

themselves in conjunction with the innovation, was a three-dimensional model which I feel conveys both the structured and unstructured elements of the implementation process.

Figure 3. A model of the implementation process for a Computer Managed Instructional system in elementary school mathematics.

The conscious adoption of a three-dimensional model is significant for two reasons: first, it implies interaction, no one element in the research setting was exclusive of any other, and secondly, it demonstrates the importance of that interaction, for to alter one element would involve a change in the structure of the entire element, a mirror, therefore, of the evolution of the research design.

However, it cannot be inferred from the representation of a dynamic situation in terms of geometric figure that as such it accounts for every aspect of the implementation process, nor that this model

would represent any implementation other than the one described here. What is maintained is that in terms of this study, a unique situation which can never be replicated, the model conveys what I feel were the essential, underlying themes.

THE MEANING OF CONFIDENCE

The meaning of confidence to the participants and its value in the implementing the innovation was clearly demonstrated by the importance of the following five sub-categories: (a) Motivation to Implement; (b) Conceptualization of the Use of the Innovation; (c) Awareness, or familiarity, with both the computer and the CMI package; (d) Reliability of the same; and (e) Accessibility to, and availability of, a consultant. While it cannot be inferred that all of these categories are unique and specific to the implementation of a technological innovation, nonetheless, the pervasive influence of technology within each of the categories is clearly evident, and in some, the most significant single factor. In chronological terms, the building of confidence began the first day of the implementation, and continued with varying degrees of intensity

amongst the seven participants until the final day.

A. MOTIVATION TO IMPLEMENT

> "Everyone's talking about computers being the new tomorrow, and... well... we've just got to know. We have no choice because either we master it, or ... well, you know, let's just say we can't ignore it. It's here and it's gonna stay. We have to know."

Beyond a common belief that computers are "the new tomorrow", and that both teachers and students must become more aware of their capabilities and uses, there were a variety of reasons for initially wanting to implement computer technology in the classroom.

One teacher responded to the pressures - real or imagined - from society ("You hear so much about them that it just seemed to me like I had to use them regardless"), while another looked upon computers as beneficial rather than oppressive ("I always thought they'd be fun so I thought it would be fun for the kids to try"). Three of the teachers had contemplated leaving education in the future, participation in the study perhaps being one means

of finding out if computers were the avenue to pursue, as evidenced by this comment:

> "I just thought it would be neat to do, because I'm not sure if I'm going to stay in teaching all my life so, you know, I'd like to branch out."

While others were looking outside of teaching, one participant foresaw a place for computers in education and wanted to know more.

> "Well... I don't know, like, I think I'd mentioned to you that I've worked with computers before, as a student, so I wasn't afraid of it to start with, and secondly, like it's been something that's been in the back of my mind for a while, I'd like to retrain in the education field but that's what I'd like to retrain in, so that I'd already thought about the possibility of approaching this field."

The importance of the student's enthusiasm in heightening or maintaining the motivation of the teacher was raised by one of the teachers after his first full week, a teacher who had volunteered to participate "because I thought it would just be neat to try!"

R: Has there been one thing, like, has something had to happen to convince you to use it, or to justify using it?

P: I think it is very motivating, the kids are always bugging me about when its their turn. So, I always do it because they want to get going.

R: And so perhaps they've helped to convince you that maybe it's useful?

P: Yeah, uh huh, because the kids wanted to use the computer I had to have it going for them.

The importance of the student's enthusiasm was for this teacher, however, short-lived, for he remarked to me during the last week of the study, "Funny, huh? The kids were all hyped up at the start and I wasn't too crazy about it now that we've had it here for so long I use it because I like it, even if some of them don't anymore!"

The influence of the student's enthusiasm had

far-reaching and significant consequences. I was greeted at the door of one classroom during the second week of the study by two parents who had been coerced to come into the school to see the microcomputer "that we've been hearing so much about". In no small way was the student's enthusiasm also important in influencing the decision of the principal to purchase a microcomputer for the school after the third week of the study. When I asked him as to the reason why he had arbitrarily chosen to purchase the microcomputer, he replied, "Why wait? The teachers love it, the kids love it, and so why wait?"

B. CONCEPTUALIZATION OF THE USE OF THE INNOVATION

> "Well initially I thought the high kids, to do extra things with them, like things we haven't done in class yet, and then I thought, no that wasn't fair. And then the low kids, they're so slow anyways, so to put them on the computer even more time is, you know, they like it, but... (pause, raising hands). And then the average kids, they never get anything extra, no extra attention or extra activities, so I thought just to give it to all of them! (laughing)"

The dilemma which confronted this participant is representative of a struggle which each teacher

fought within themselves as to who would get to use the computer and why. However, regardless of the original plans of the participants, each and every one resorted to a routine, democratic system when the computers were introduced into the classroom. This phenomenon will be discussed in greater detail at a later point, for it has implications which deserve greater elaboration. Nonetheless, as to who would use the computer, there were initially two streams of thought: for the exceptional pupils both as enrichment and remediation, or equally for all students regardless of ability.

The question of computer availability, or the lack of it - each classroom had a computer for one half day every day - had a definite influence upon the decisions the teachers arrived at as to how it was used on a daily basis.

R: Did you have any idea beforehand about how you would use the computer, like, did you have any idea you would use it the way you are now?

P: Well, I was concerned about having all of my students use it.

R: You think that's very important?

P: Well I like that, and I was afraid I'd only be restricted to using it with a few in which case I would have used it as a remedial purpose, probably. But in which I didn't see that as being fair, because being something new to the kids it's almost like a reward, and the kids who don't do their work or who don't listen in class and so don't get ahead would get to use it. So I was afraid that if I had to use it that way I wouldn't be satisfied.

The 'how' of computer use, then, was influenced by computer availability and the degree of student enthusiasm. This "novelty" effect did not diminish over the entire nine weeks of the study, and must be recognized as an important dynamic which pervaded many of the decisions made by the teachers regarding the use of the computer.

Of the seven participants, only one thought of using the CMI package for a purpose other than review or drill and practise...

> "What I find though is that toward the end of the year I want to get specifically which kids can add, which kids can subtract, you know with regrouping and that, and I think this'll help me a lot to prepare them for their final test."

When asked if bringing the computer in during September would have made a difference the participant commented that "yeah, probably, I'd use it for review from the previous year."

C. AWARENESS OF THE INNOVATION

The awareness which I felt was so important to the participants was an extension, a deeper understanding, of both the machine and the program which were introduced in a "literacy program" preceding the implementation. The uniqueness, capability and complexity of the innovation, and the "aura" which surrounded it ("I'd heard that computers can do everything we can only better"), necessitated a cautious approach both on my part in introducing it,

and the teachers in learning about computer technology. A characteristic common to all of the teachers was a degree of intimidation and fear which detracted from their motivation and enthusiasm.

The "functional literacy" introduction, albeit superficial, was necessary for the teachers to begin using the computer, but the need to know more spurned each of them on to delve deeper into the program's capabilities.

> P: I don't know, I guess the only thing is I felt I wanted to know what they would be doing when they were there, like, that was what I was mostly concerned about, you know, looking at what they'd be doing or how the machine would respond to what they'd been doing.
>
> R: And now you think you know?
>
> P: Well, I feel I know what's happening on there so that when I go, and if I look back on their progress, you know, I have an idea of what they've done, or what they're

capable of doing.

R: Did you have to work through it yourself, even though we'd discussed and worked through it last week (at the inservice)?

P: Well some of it I did, like, I could look at your sheets (the objectives for each operation and the management programs) to know what type of work they'd be doing, but what I was interested in was how the computer would respond, say, to so many wrong answers. You know, things like that, so that the kids would know what to expect and I knew, like, you know, it's actually doing my job in a small way so I wanted to know what it was doing.

When asked if the inservice might have proven more beneficial if it had explained in greater detail both the capabilities and intended uses of each of the five management programs, the general agreement was "yeah, but even so, you basically have to learn it by doing it."

Whereas an intimate knowledge of each program in the CMI package was vital for every teacher, a deeper understanding of the operation of the computer was not valued consistently by them all. The general feeling was echoed by one teacher, that "I could have worked with it without knowing all the parts and stuff, as long as it's operating", but three teachers did ask for a more detailed explanation of the data storage and retrieval, one explaining, "I just couldn't imagine how it could do all that inside those little, black boxes!"

D. RELIABILITY OF THE INNOVATION

> "I thought that I felt comfortable enough with it, but, suddenly, when all these little things were happening, and I take it's because of the students, but suddenly then I felt like, you know, what's wrong? And then I started thinking about myself, because what if I'm the only class, why isn't this class getting it, sort of thing? So then I started to feel a little unprepared."

Of the five components which together formed the confidence of the participating teachers, a fact unique to the implementation of a technological innovation, the reliability of both the computer and the program, was of paramount importance. Amongst

the seven teachers, five experienced some form of unreliability: two with the software (the incorrect selection of options by the students which resulted in inappropriate test generation and incorrect data manipulation) and three with the hardware (disk drive malfunctions on two occasions and damaged diskettes on three others).

The greatest negative impact of unreliability was on the motivation of the teachers, "a feeling that it wasn't worth all the aggravation." The anxiety, frustration, and a sense of helplessness compounded the initial feelings of intimidation and fear, and was a recurring theme between the teachers who had shared the negative experience.

The experience of one teacher was especially frustrating, because the problems which occurred and the reason for their being was obscured initially by electrical problems related to the air conditioning units in the classroom. Fluctuations in the electrical power when the air conditioning units were activated by thermostatic control were initially believed to be at the root of problems which kept reoccuring in data storage and retrieval.

However, I observed the students for a period of two consecutive afternoons and found that they were providing incorrect information to the program when given a series of options. Consequently, two students were assigned to monitor the others and no further problems were noted.

One important factor which served to heighten the emotions of the participants was the six week original time limit on using the computers.

> "Well at first I thought, aw gee, you know, if I don't get started maybe I shouldn't, you know, go ahead with it because if I won't have time to make use of it, maybe it's not worth even starting."

The unreliability of the computer, or the CMI program, retarded the rate of acquisition of knowledge about the management programs by the teachers, because as one commented, "you know, when things went well for a while after we had those problems, I was afraid to do anything in case I wrecked it, so I just let well enough alone."

The importance of a consultant, readily available and easily accessible, was clearly

emphasized by these problems, both to correct and appease.

E. ACCESSIBILITY TO, AND AVAILABILITY OF, A CONSULTANT

The original intention of gradually diminishing in importance my role as consultant when implementing the innovation could not be maintained during the study for a variety of reasons: (a) the complexity of the innovation and the unfamiliarity of the participants both with the mechanics of the computer and the program; (b) the uniqueness of the innovation as something which demanded continual support and encouragement on my part; and (c) the unreliability of both the computers and program which meant that as "resident expert", I was called upon to correct any defect or fault when it occurred. However, my presence in the research setting as consultant was important for reasons other than technical, and regardless of whether the machine and program performed correctly or not. My role also included that of supporter and morale booster, someone who had a history in working with the machine and so could pass on the comfort and familiarity I felt.

> It was really motivating to have you here knowing that you've worked with these and you know how they work. Like, I think if I had gotten just the book and the machine I might have eventually turned it on and tried, but I would have been a lot more insecure.

By continually reassuring the teachers that experimenting with the program could not in any way harm either the machine, the program or the student's records, I also acted as a sounding board which the participants used to proclaim some new discovery. It is interesting to note that I was always the first to know when something productive had occurred, as well as when something negative, even though the participants freely shared information and experiences.

Finally, the accessibility to, and the availability of, a consultant, was important as a stimulant for action.

> I think when we heard that someone would be coming out to do this research work, that quite a few of us were quite excited about getting involved. But if you hadn't have been here, like if somebody had just dropped off these computers and stuff, they'd probably still be sitting in the office.

THE ROLE OF ESTABLISHMENT

Establishment was the process by which confidence was slowly built in the participants, a routine, democratic use of the machine that emphasized the review of concepts far below the student's capabilities. Efficiency in terms of the number of students per day using the computer (a function of the concept of the computer as a "novelty" and the six week time limitation) and accommodation with a minimum amount of disruption (a function of confidence-building) were the two main characteristics of this second dimension.

The establishment process was dependent to a large extent upon the (a) Availability of the innovation; it's development was guided by (b) Need or necessity; and it was illustrated through (c) Democratic, routine use,

A. AVAILABILITY OF THE INNOVATION

The importance of having the computer for large blocks of time on a regular basis as opposed to timetabled use had an impact on both who would use

the computer and how that use might be organized.

R: So you like everybody using it?

P: Uh huh.

R: You find that is the most efficient way of using it?

P: Well, that's the way I like it, but to do that I have to have it in my room, I have to have the use of it, at least half a day. Every other day the child gets to use it, like, if they only got to do it once a week, I don't know, I don't think there'd be much use to it that way.

R: And it wouldn't be of any use to you either, you don't think?

P: Well, sure, it would be, but then I couldn't use it this way. I'd have to use it for remedial, and hopefully, I'd be smart enough to put together something so I could use it for enrichment, you know what I mean?

So the top kids got a chance to extra work on it too, when they were finished.

The importance of the availability of the computer in the short term was accentuated by the long term constraints of a six week study.

R: Is it all that important having it for a large block of time?

P: Oh yeah, for sure.

R: Any reason why?

P: Well... it might be because we only have them for so long, like, I'm sure if we had them for the whole year it wouldn't matter as much. But, when you only have it for six weeks, you know, you do want to get through a certain amount, or whatever.

B. NEED, OR NECESSITY

The perceived need of the teachers to use the computer underwent a gradual shift in emphasis, from

a need to know based on a mixture of curiosity, unfamiliarity and novelty, to a need for the computer to assume more of a role in the instruction of mathematics.

R: Did you use the programs whenever the need arose, or was there something else which made you go over and use it in your spare time?

P: I was kind of excited about it at first, so it wasn't that I had to do it. I just wanted to figure out a few things.

R: Has the novelty wore off?

P: Yeah (laughing), I think so.

R: How do you look on it now?

P: Well now I'd go to it when I had to, or, you know, like, if I decide to put them into groups or something. Before, I was doing that just for the sake of trying it out.

This interpretation is substantiated by the comments of another participant during a group interview session.

> "I was willing to experiment with it and to spend some time with it because I felt it was important for me to get to know what it is doing, but now, I go to it because I have to, I need to, (laughing), no, no, I go to it because it can do something I just don't have the time for, or maybe I couldn't do as good ... honestly!"

It was interesting to note the confidence of the participant (and the other participants in the group session who all seemed to concur with her comment) both as to the reliability of the program and their familiarity with it. Here again, the interaction between the dimensions of confidence and establishment is quite clear, that establishment was a product of, and yet at the same time a means of producing, confidence. The participant's need to know at first based on their motivation to participate, but changed as the reliability of the program improved, and they became more familiar with it's capabilities.

The need to know had another dimension to it,

the expansion of the need to know about the role of computers in the classroom from the original seven participants to other members of the staff who envisaged other potential uses for the technology in their area of speciality. I was approached at various times by the kindergarten teacher, the music teacher, the French teacher (who had participated in the literacy classes during the first week), and the librarian. In addition, I was told by one of the participants during the last week of the study that many teachers who had not volunteered to participate now regretted doing so.

C. DEMOCRATIC, ROUTINE USE OF THE INNOVATION

In the same way that my best intentions regarding aspects of the research design were tempered by reality, so too were the participant's original conceptualizations as to how to use the computer, and for whom. The novelty and the uniqueness of the innovation, the enthusiasm of the students, the time constraints, and the uneasiness of the participants with the technology were all mitigating factors in the decision to use

the computer on an equal basis for all students all of the time, at least initially.

R: Had you thought about using it with a particular group of kids or do you want to use it for everybody all of the time?

P1: I think from the kid's point of view I'd like to use it with all of them, some of them more than others maybe later on, yeah, maybe towards the end have them all go through once and then certain kids go through twice, or something, but not for a long time yet.

R: Could you bring this thing in (tapping the computer), let everybody have one turn, like, would that satisfy them and then simply use it for three or four of them on a day to day basis, say?

P2: No, not with my bunch (Grade Six).

P3: No, I couldn't see that either. It might

at a certain age level, do you think, but I know here in Grade Three, they're so, they like to do their own picture, their own craft type of thing, and they like to take home and show mom and dad.

R: So they all have to have a turn doing their own thing.

P1: Right, that's important.

R: Is that as much for you as it is for them?

P3: I don't know what you mean?

P2: You mean, like, making life easier for us, you know, no hassles or stuff?

R: Yeah, I guess so, like, are you still trying to get comfortable with it?

P3: Oh, I know, yeah, I suppose.

P1: But you know, for this part, I think if the kids were on the computer say last year,

> and they got the computer again this year, then they wouldn't all want to be on it I don't think, but more, you know, just because its new more than anything else.

While the fairness or equality aspect of using the computers was a constant during the entire length of the study, both the confidence of the teachers in themselves and the machine, and a growing awareness of the capabilities of the program and the way in which they might be incorporated, as opposed to accommodated, into the classroom were dynamic forces for change.

INCORPORATION: CONFIDENCE AND AWARENESS

Incorporation, or the increasingly sophisticated use of the CMI program, reflected a change in the motivation to implement the innovation from without ("the new tomorrow") to within ("now I use it because it helps me out"). This change was a result of the confidence-building phase and the facilitating establishment routine. The watermarks of the corresponding growth in confidence and program

awareness were the capabilities of the CMI program employed by the teachers.

Initially, the program was used in the most elementary fashion, with each student beginning at the first objective in one operation. The purpose of this was seemingly two-fold: to acquaint the student with the operation of the program in an orderly routine, and to help establish some degree of confidence in the teacher.

> R: Could you basically describe for me exactly how you are using it?
>
> P: Okay, initially, just to get the kids used to signing on to the computer and have some experience with it, we were working at a level that was quite easy, it wasn't anything taxing on any of the children, the bright or the average or the slower kids.
>
> R: And so would you basically call that review?

P: Um, no, it wasn't even review. It was very, very primary kinds of things, but it was just for you, you know, to feel comfortable and to get the experience that I can get into the program fine. Then once, um, we did that for a couple of weeks.

R: Was that for yourself as much as for the kids?

P: Um, probably, yes, yeah, okay.

The second stage was the management of the assignments for individual students or the class as a whole. In effect, this moved the students closer, but not yet up to, their instructional level. The single most significant factor in the progression from the first stage to the second was the reliability of the innovation as it related to confidence-building. Thus, the rate of incorporation, and consequently the degree of incorporation, was almost entirely dependent upon the degree of teacher confidence during the process of, establishment.

What eventually proved to be the apex of

sophistication in using the CMI program was attained by three of the seven teachers during the eighth of the nine weeks in the study. Large, homogenous groups formed on the basis of achievement in the objectives (yet still in the routine democratic context of usage), were established for review of previously taught concepts.

> P: I grouped the class into three groups, a high group which was made up of about one third of the class, or one fifth of the class, a middle group, then a slower group, and then we gave each group a name ...What I have done since then is, each group is working on a different objective, so there's a variety of ability levels. The way I've worked how the time is spent on the computer is we start at for example, the Micros, and the first person at the top of the list starts. We proceed like that 'till everyone in the Micros has had a turn. Once the last person in the Micros has had a turn, we go to the top person in the next group either the Chips or the Discs.

R: And so they're still in a routine?

P: Yes, very much so.

Although by the end of the study the teachers were assigning objectives, grouping students and more closely monitoring their progress, still the assumption that "when appropriate information is supplied to instructional decision-makers in a usable format,efficiency and quality of decision-making improve" (Spuck & Bozeman, pp. 33) was never realized during the study. The only instructional decisions made were those of the CMI program itself, advancing, holding, or retarding the progress of the students up the hierarchy of objectives according to the predetermined criteria of failure and mastery.

The use of the Report Management Program in conjunction with the Prescription Management Program to formulate and activate instructional strategies was marginal at best. All of the teachers used the Report Management Program to assess individual performance, however, no action as to remediation or re-assignment was ever undertaken. Sophistication of use, therefore, refers only to the utilization

of but a small portion of the total capabilities of the CMI package, specifically assigning and grouping, which lies somewhere between unmanaged, routine usage of the program at inappropriate objective levels (the entry point), and quality decision-making based on individual needs and abilities (the theoretical goal).

SUMMARY

The implementation of a Computer Managed Instructional system in elementary school mathematics was characterized by three dominant themes. The themes, which I have chosen to represent in a three dimensional model, were the result of the interaction between the participants, and between the participants and the innovation. The first dimension, the building up of confidence in the teachers, was as significant from the inception of the program as it was at its conclusion. The confidence of the teachers was dependant upon a motivation to participate, the reliability of the innovation, an awareness of the program's capabilities, a conceptualization about who should use the program and how that use might best be organized, and the availability of, and accessibility to, a consultant.

The second theme, the accommodation or establishment of the innovation, was at once the means of producing, and the product of, the growing confidence that the participants felt in themselves and the innovation. The establishment phase was dependent upon the availability of the computer, guided by the need of the teachers to use the program whose focus shifted from external ("the new tomorrow") to internal (intrinsic value of its own), and illustrated by routine, democratic use. The third dimension was the incorporation of the innovation into the instructional strategy of the participants, a lock-step sequence of uses that grew in sophistication from the assigning of objectives to the grouping of students based on achievement.

CHAPTER FIVE

SUMMARY, FINDINGS AND DISCUSSION

This study of the implementation of a CMI system was an outgrowth of both the phenomenal rise in the popularity and availability of computer technology in education, and my personal interest in the applicability of a computerized management system for elementary school mathematics. The first step, the design and authoring of a CMI package for the Apple II plus microcomputer with a single disk drive and Silentype thermal printer, was necessitated by the commercial unavailability of such a system.

While the core of the system (an instructional data base consisting of a hierarchy of objectives for each of the four computational operations and five management programs) remained virtually intact for the length of the study, nonetheless, revisions to the original specifications of the system began with the pilot study and continued until the culmination of the research. In particular, the test generation and scoring cycle was substantially revised to enhance the efficiency of operation both in terms of data

manipulation and time and minor modifications to options within the management programs were made after use by the participating teachers.

The research study, conducted in an elementary school serving a community of six thousand, involved seven teachers and one hundred and fifty-six students spanning grades three to six. As a collective, few common traits could be established for the teachers, especially as regards previous experience with computers, the mathematics program, and implementing an innovation. The students, on the other hand were uniformly familiar with, or had access to, some variation of integrated circuit technology.

A "functional literacy" program consisting of three, one-half hour lessons, served as an introduction to microcomputers in general and the CMI program in particular. Further to the brief familiarization lessons, the teachers were given an in-service demonstrating the capabilities and operation of the program, and the students were monitored by myself on an individual basis when they first used the program. While my role as researcher began with the introductory phase, the others I had assumed - creator, author,

consultant and implementer - did not simultaneously end at that point in time. Rather, each assumed varying degrees of significance at different times during the research, both to generate and collect data.

As the implementation process unfolded, there emerged a number of themes which characterized the initial process of accomodation and the subsequent incorporation of the CMI system into the instructional methods of the participating teachers. The representation of those themes was attempted with the development of a three-dimensional model of implementation emphasizing the relative importance of confidence-building and routine usage upon the degree of incorporation.

FINDINGS AND DISCUSSION

While the rapidity and magnitude of change in society today constitutes a veritable revolution unparalleled in modern times, change within education promises to continue to be a slow and complex process. The uncertainty about the role of computers in education and the fear and trepidation felt by many

teachers when confronted with such technology, constitute the two, single most important reasons why change towards greater integration of computers into every aspect of education is only now gaining momentum.

In an effort to enhance the understanding of the implementation of an innovation, many theories have been advanced as to the dynamics of the situation and the requisite strategies to be employed to determine the degree of implementation. Berman and McLaughlin (1976) identified three stages of implementation: initiation, implementation, and incorporation (pp. 351). Hall et al. (1975) conceptualized implementation in terms of progression from orienting to managing to integrating (pp. 52).

Berman et al. (1976) sub-categorized their three stages of implementation to illustrate the underlying factors promoting change. Within the initiation stage they identified the presence of a good idea, the availability of funds, local needs, and the incentives of the individual actors; implementation was based upon the motivations and circumstances involved in its initiation, its substance and scope

of proposed change, and its strategy; while incorporation was the process of continuation of the innovation beyond the implementation stage (pp. 351-354).

The tripartite framework of the implementation process was reiterated by Hall et al. (1975) in an eight level model which emphasized three distinct, hierarchial stages: orientation, management, and integration.

> Before actual use, the individual becomes familiar with and increasingly knowledgeable about the innovation. First use is typically disjointed, with management problems quite common. With continued use, management becomes routine, and the user is able to direct more effort toward increased effectiveness for the learners and integrate what (s)he is doing with what others are doing (pp. 52).

The three stages were subdivided into eight levels of use of the innovation: (1) non-use, (2) orientation, or information acquisition, (3) preparation, (4) mechanical use for familiarization, (5) routine pattern of use, (6) refinement of the use of the innovation based on formal or informal evaluation, (7) integration based on coordination with colleagues, and (8) renewal, or the exploration of alternatives to or modifications of the innovation (pp. 54).

Research, therefore, has established frameworks of implementation based to a large extent on identifiable stages within which certain themes or forces are at work. In relating the findings of the researchers previously mentioned to the findings of my research the following points for discussion are presented:

1. As a general framework or structure within which to conceptualize the implementation process, each study identified three stages which illustrate a preparation for implementation: initiation, or in terms of this research study, confidence-building; implementation of the innovation in a routine, mechanical fashion (implementation, and establishment); and finally, some degree of incorporation as the innovation is more fully integrated into the instructional cycle. Within each stage, recognizable elements were noted as depicting or characterizing the stage: the presence of a good idea, local needs, incentives of the actors, orientation, preparation, reliability, awareness of the innovation etc. for the preparation stage; mechanical use, routine, mutual adaptation, availability of the innovation and sophistication based on need or necessity for the implementation; and finally the incorporation of the innovation or refinement,

integration and renewal. While research to date has focused on the implementation of a non-technological innovation, nonetheless, similar themes or categories would appear to be important in the implementation process involving a CMI system. The single exception, and one entirely dependent upon the complexity and capabilities of the innovation, would be the importance of the reliability of the computer and the related software.

2. In contrast to the Hall et al. (1975) model of implementation which defined levels of use in a hierarchial fashion, my findings showed that no such linear relationship existed between the elements of one stage alone or in concert with another. The complex interaction between the categories, as for example between the elements involved in the confidence-building and establishment stages, was a process of mutual adaptation in which the establishment stage was at the same time a means of producing and the result of, confidence-building. A closer theoretical relationship exists, however, between the model I propose and that advanced by Common (1979), in which she represented the implementation process as a relationship between the three dimensions of curriculum, user

and organization (pp. 19). My research substantiates the interactive nature of the stages of implementation in an evolutionary process, and proposes that the relationship is manifested in a confidence-building phase based upon the establishment of a routine and leading to a more sophisticated incorporation of the innovation.

3. In terms of this study, the inappropriateness of representing the implementation process in terms of a hierarchial, linear model, means that as such, "decision points", which directed the rate and direction of the implementation were redundant. Decisions which were made were oftentimes as much horizontal in origin or effect as they were vertical, in other words, the participating teacher's decision to know more about the innovation (awareness) was influenced by related categories within the same theme, such as the reliability of the innovation or a motivation to participate. In addition, decisions as to whether or not to utilize the management aspects of the CMI package were influenced by my presence in the research situation as creator and implementer as much as they were indicative of an increasing level of usage.

4. The importance of the availability of, and

accessibility to a consultant during the implementation process of this research study cannot be stated clearly enough. The immediacy of the consultation had important ramifications for the efficiency and smooth operation of a highly technical and complex innovation. The minimal knowledge of the participants regarding the innovation meant that unreliability of the program or insecurity on their part in utilizing the management routines only promoted frustration and a lack of confidence. In addition, the personalization of the implementation served to ease fears and calm uneasiness both over the initial accomodation of the innovation and experimentation with it. The "Mr. Apple" phenomenom was clearly evident in many of the interactions I had with both teachers and students, and I feel that acceptance of the CMI package was at least in part attributible to the teachers rapport with myself. The consultant, readily available and easily accessible was, therefore, an integral component of the implementation and in many ways vital to the continuation and eventual incorporation of the innovation.

5. The benefits and consequences of having the creator and implementer of an innovation be at the

same time the consultant and researcher are implicit throughout this study. The personal committment which I felt towards the implementation process no doubt had some effect on the quality of the implementation strategy which I wanted to establish. Similarly, my intimate knowledge with every aspect of the CMI program quickly alleviated many of the unreliability problems which characterized the early stages of the implementation. However, the integrity of the research role was in constant jeopardy because of my previous experience in the role of the participants, my familiarity with the program, and my role as consultant whose importance only diminished marginally over the course of the study. The benefits to be gained from such proximity to the research setting included a deep and mutual understanding between myself and the partipants which enhanced the data and the significance of my findings is due in no small measure to the many perspectives and roles which I brought to the research.

6. The general theme, or tone, of both the research study and the implementation process was one of evolution. The design of the study was molded by the reality of the situation, just as the CMI package was altered by demands and needs of the participating teachers. The

resultant model of implementation emerged slowly from the thoughts and actions of the participants rather than appearing in a neat, concise, readily identifiable manner. This theme of evolution of change is in accord with the findings of Berman and McLaughlin (1976, pp. 353) and Common (1979, pp. 17) who emphasized the significance of mutual adaptation as the cornerstone of implementation.

> The inevitable outcome and goal of the continuous implementation process is one of mutual adaptation. All elements are altered in the process. The degree of alteration is determined by the dynamics of the total process (Common, 1979, pp. 17).

In terms of my research study, the mutual adaptation began with the pilot project and continued throughout the length of the research study. The adaptation on the part of the CMI program was initially greater than that of the participating teachers. However, with the increasing sophistication of use, it was obvious that some degree of adaptation in terms of teaching strategies was undertaken. In extrapolating the incorporation stage beyond the findings of the research, it is conceivable that the assigning of objectives, grouping students and managing more effectively the

work and progress of the students, would ultimately lead to some degree of individualization. Such a teaching model would be indicative of a significant departure from the initial teaching styles of the seven teachers. Mutual adaptation was therefore an important dynamic for change operating within the context of confidence-building, establishment and eventual incorporation.

7. The rate of, and consequently the degree of, implementation, was most sensitive to the reliability of both the hardware and the software components of the CMI package. Unreliability affected not only the confidence of the participating teachers, but also their motivation to continue and their willingness to experiment with the capabilities of the program. Consequently, their development in using the program beyond the establishment stage was somewhat retarded. The implications for future implementation projects using such complex technology are obvious, namely that every effort must be made to ensure that both the hardware, and especially the software, function correctly and consistently. In ensuring such to the degree that is possible when working with technology, the rate and degree of implementation will be

improved greatly.

8. The need to establish a facilitating routine in order to establish some degree of confidence was vitally important, despite the initial conceptualizations which all of the participating teachers held before the implementation began. This action is in accord with the mechanical use and routine identified by Hall et al. (1976), specifically to provide a breathing space in which the teacher can accomodate the innovation without disrupting the schedule and teaching methods presently in use in the classroom. By going to the innovation only when the need arose, the teachers were able to familiarize themselves with the technology and the program on their terms and according to their schedule. It also is interesting to note that the initial conceptualizations never materialized, a function of the principles of fairness and equality which were influenced by the limited availability of the computer, and the increasing awareness by the teachers of the far-reaching implications of the CMI program for all students of all abilities.

9. The implementation strategies selected to

carry out a project vitally influence the innovative process and project outcomes (Berman & McLaughlin, 1975, pp. 359). The implementation strategy adopted for this research study was a functional literacy program for the students with a minimal awareness component about the innovation, and an inservice component for the teachers on the mechanics of the program and its capabilities. In addition, each student was monitored on an individual basis when they first interacted with the computer. The seven classes were then encouraged to begin the implementation as soon as it was convenient. Consequently, after some minor logistics problems with the sharing of machines, all the classrooms began implementation at approximately the same time. The role of the consultant during this phase was proposed as quickly diminishing in importance, based upon the assumption that very few problems would occur with either the hardware or the software. The net result was an extremely hectic and frantic period during which I as implementer was responsible for the smooth and efficient operation of seven programs, all the while called upon repeatedly for advice and assistance. I would recommend, therefore, that future implementations of computer technology be approached in a slow, deliberate

fashion with a minimum of participants so that the availability of the consultant is enhanced and the confidence-building of the participants is maximized.

The process of implementation, therefore, is a complex process which demands a great deal of effort, commitment and expertise on behalf of both participants and implementer. The need of the participants for guidance, support and encouragement must be met by a personal, committed, and thoroughly knowledgeable implementer. These essential ingredients, combined with time to allow the confidence of the participants to grow and an awareness of the capabilities of the program to be developed, will provide the foundation for a successful, productive incorporation of computer technology into the elementary school classroom.

CHAPTER SIX

IMPLICATIONS AND CONCLUSION

The uniqueness of a study of this type, undertaken in a field still in its infancy, generates far more questions than answers. One thing we can be sure of is that as the societal push to teach children about computers and the expanding powers and capabilities of the computers demand that we integrate them into the daily routine of the classroom, so the researcher will be there also, probing and inquiring into the positive and negative effects. This study, as one link in a growing chain which is seeking answers and raising questions about the role of computers in education, has implications for the researcher, the implementer of a technological innovation, the administrator, and the educator.

Implementation, a complex and intricate process is complicated still further when a technology such as a computer is introduced. The fear and trepidation felt by many teachers demands that we personalize the process as much as possible, make it a slow, controlled highly supportive incorporation at a rate and degree suited to the confidence, needs and wishes of the

individual teacher. While the "halo" which surrounds the awesome potential of the computer entices some to become actively involved, many still reject outright any thought of working with the technology, especially teachers in the lower grade levels. Only by bridging that gap with understanding, patience, and the best of human qualities can we promote the growth of computer use throughout the range of grades. One means to that end which immediately comes to mind is a literacy program for teachers of all levels, to overcome the prejudice, and expose the promises and pitfalls of computers to educators. Longitudinal research must be undertaken to examine more closely the cognitive and affective effects on both teachers and students of extended computer use, particularly in regards to CMI, which I consider to be a key element in any computer assisted instructional program. Literacy for the teachers, therefore, must go hand in hand with research into the relative merits and value of the computer itself in education, the components of CMI systems alone, or as an element of a CAI system for remediation or drill and practise purposes.

The dynamic state of the technology field will continue to advance the boundaries of both computers'

capabilities and capacities, thus increasing the potential for small, relatively inexpensive systems in the classroom. One can even now envisage an on-line, interactive mode of CMI or CAI with full management capabilities to streamline the inefficient and disruptive hard-copy procedures which the participants employed in this study. When such is the case, then we can expect a great deal of revision to the process of implementation as described herein. This study will then become the context for further research, and another link in the chain will have been forged.

CONCLUSION

The potential of computer technology to enhance the daily operation of the classroom and lighten the burden of mechanical, managerial functions which teachers are called upon to perform, is enormous. Up to the present time, however, very little has been attempted, let alone achieved, which would support an optimistic outlook for the incorporation of such technology, and the matching of the popularity for the content, with an equal enthusiasm for the process impact of computers in education. But as was clearly evident throughout the course of this study, and especially so in the

latter stages, the rationale for the use of Computer Managed Instructional programs lies in the enthusiasm of the participating teachers. The means and methods to the successful implementation, however, will require a careful, deliberate, personal approach which guides and supports as opposed to expects and demands.

Because we find ourselves still in the formative stage as regards the incorporation of microcomputers in education, the potential for the uses of microcomputers is matched by the potential for educators to determine the nature and direction of such uses. I am hopeful that this research study is in some small way indicative of a greater emphasis yet to come in this field.

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APPENDIX A

CURRICULUM OBJECTIVES

CMI MATHEMATICS SYSTEM OBJECTIVES

ADDITION OBJECTIVES

1. SUMS TO 6
2. SUMS 7-10
3. SUMS 0-10
4. SUMS 0-18
5. THREE ADDENDS
   - SUMS TO 10
   - SUMS TO 19
   - SUMS TO 27
6. TWO DIGIT ADDITION
   - NO REGROUPING
   - REGROUPING POSSIBLE
7. THREE ADDENDS (ONE AND TWO DIGITS)
8. TWO AND THREE DIGIT ADDITION
   - NO REGROUPING
   - REGROUPING POSSIBLE
9. THREE DIGIT ADDITION
   - ONE AND TWO REGROUPINGS POSSIBLE

CMI MATHEMATICS SYSTEM OBJECTIVES

SUBTRACTION OBJECTIVES

1. MINUENDS TO 6
2. MINUENDS TO 10
3. MINUENDS TO 18
4. MISSING MINUENDS TO 10
5. MISSING MINUENDS TO 18
6. ONE AND TWO DIGIT SUBTRACTION
   - ONE REGROUPING POSSIBLE
7. TWO DIGIT SUBTRACTION
   - NO REGROUPING
   - REGROUPING POSSIBLE
8. THREE DIGIT SUBTRACTION
   - NO REGROUPING
   - REGROUPING POSSIBLE IN ONES
   - REGROUPING POSSIBLE IN TENS
   - REGROUPING POSSIBLE IN ONES/TENS

CMI MATHEMATICS SYSTEM OBJECTIVES

MULTIPLICATION OBJECTIVES

1. ONE FACTOR 0-5/ONE FACTOR 0-5 & 10
2. ONE FACTOR 6-9/ONE FACTOR 0-5 & 10
3. ONE FACTOR 0-9/ONE FACTOR 0-10
4. TWO DIGIT BY ONE DIGIT
   - NO REGROUPING
   - REGROUPING POSSIBLE
5. TWO DIGIT BY TWO DIGIT
   - MULTIPLES OF 10/NO REGROUPING
   - MULTIPLES OF 10/REGROUPING
   - NO REGROUPING
   - REGROUPING POSSIBLE
6. THREE DIGIT BY TWO DIGIT
   - NO REGROUPING
   - REGROUPING POSSIBLE

CMI MATHEMATICS SYSTEM OBJECTIVES

DIVISION OBJECTIVES

1. DIVISORS 1-5 & 10
2. DIVISORS 6-10
3. DIVISORS 1-10
4. ONE DIGIT DIVISORS AND QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE
5. ONE DIGIT DIVISORS/TWO DIGIT QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE
6. ONE DIGIT DIVISORS/THREE DIGIT QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE
7. ONE DIGIT DIVISORS/FOUR DIGIT QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE
8. TWO DIGIT DIVISORS/TWO DIGIT QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE
9. TWO DIGIT DIVISORS/THREE DIGIT QUOTIENTS
   - NO REMAINDERS
   - REMAINDERS POSSIBLE

APPENDIX B

MANAGEMENT PROGRAMS

COMPUTER MANAGED INSTRUCTION MATHEMATICS SYSTEM

A. MAIN MENU

1. STUDENT TEST PROGRAM
2. STUDENT MANAGEMENT PROGRAM
3. CLASS MANAGEMENT PROGRAM
4. PRESCRIPTION MANAGEMENT PROGRAM
5. DISPLAY MANAGEMENT PROGRAM
6. RECORD MANAGEMENT PROGRAM
7. EXIT

B. STUDENT MANAGEMENT PROGRAM

1. VIEW STUDENT BIOGRAPHY
2. CHANGE STUDENT BIOGRAPHY
3. MAKE AN ASSIGNMENT
4. VIEW STUDENT HISTORY
5. EXIT

C. CLASS MANAGEMENT PROGRAM

1. ADD A STUDENT
2. DELETE A STUDENT
3. VIEW STUDENT GROUPS
4. GROUP STUDENTS
5. VIEW STUDENT ASSIGNMENTS
6. EXIT

D. PRESCRIPTION MANAGEMENT PROGRAM

1. VIEW OBJECTIVES/PRESCRIPTIONS
2. VIEW AN OBJECTIVE
    - ADD A PRESCRIPTION
    - CHANGE A PRESCRIPTION
    - DELETE A PRESCRIPTION
3. EXIT

E. DISPLAY MANAGEMENT PROGRAM

1. STUDENT STATUS PROGRAM
2. CLASS STATUS PROGRAM
3. OBJECTIVE STATUS PROGRAM
4. EXIT

APPENDIX C

INSTRUCTIONAL MANAGEMENT REPORT

NAME: JONES JACK

OPERATION: ADDITION

OBJECTIVE: 2 DGT ADD-NO REGR

** STUDENT ****** TEST RESULTS *****************

1. 15	1. 15
2. 13	2. 13
3. 12	3. 13
4. 27	4. 27
5. 18	5. 19
6. 46	6. 46
7. 82	7. 82
8. 60	8. 60
9. 54	9. 55

TOTAL CORRECT: 6

****************** GROUPINGS ******************

ANDERSON SUE

SMITH JOHN

PETERS BOB

PERSON JILL

***************** PRESCRIPTIONS ***************

1. CH5.No1,2,3
2. PICTURES
3. STENCIL 6,14,15
4. ***************
5. ***************

APPENDIX D

INTERVIEW ORGANIZATIONAL MATRIX

	Functioning	Utilization	Effects
	Do the components of the system operate correctly?	For which management processes is the system being used?	Which are the effects of using the system?
ACTUAL	1. Programming error detection and correction. 2. The accuracy and clarity of the reports.	1. Record the number and type of accesses by both students and teachers each day and over time.	1. Student achievement gains as the difference in number of objectives mastered between a pre- and post-test.
PERCEPTUAL	1. Describe the operation of the CMI system. 2. Describe each of the 6 components of the system and their contributions to the overall design.	1. Describe the role of a teacher using a CMI system. 2. Describe each of the 4 management programs.	1. Describe any changes in the student's role in the learning process. 2. Describe any changes in your role as teacher in the learning process. 3. Describe any classroom disruptions from using a computer.
JUDGEMENTAL	1. Were the instructions clear and easy to understand? 2. Was changing information difficult to do? 3. Which of the 4 programs could be improved, and in what ways?	1. How do you feel about the accuracy and value of using a CMI system? 2. Which of the 4 programs was most valuable? 3. If you had the choice to use a CMI system again, would you?	1. What effects did the CMI system have on the class? 2. What effects did the CMI have on you as a teacher?

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